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MARINE AND COASTAL BIOLOGICAL DIVERSITY: IMPLEMENTATION TOOLS FOR THE PROGRAMME OF WORK AND ANALYSIS OF CORAL BLEACHING

Note by the Executive Secretary

EXECUTIVE SUMMARY

The present note deals with two issues: (i) tools for the implementation of the programme of work on the conservation and sustainable use of marine and coastal biological diversity; and (ii) analysis of coral bleaching. With regard to the tools, the note describes the tools used for the implementation of the programme of work at the international level. These tools are also beneficial and complementary to the tools and mechanisms used by the Parties while implementing the programme of work at the national level. The description includes the uses of the tools, their efficiency, criteria of success, limitations, and lessons learned from their uses.

The analysis of the coral-bleaching phenomenon has been prepared to assist SBSTTA in responding to decision IV/5, section II, paragraph 1, of the Conference of the Parties, requesting the Subsidiary Body to make the analysis of, and provide relevant information on, that phenomenon to the fifth meeting of the Conference of the Parties for its consideration. The relevant section of this note first highlights the importance of coral reefs and then discusses possible causes of coral bleaching, the potentially severe loss of biological diversity and consequent socio-economic impacts. This note benefited from inputs from an Expert Consultation on Coral Bleaching, organized by the Executive Secretary to identify the main scientific, technical and technological aspects related to the problem. It also gives examples of current measures to address the phenomenon. The full report of the Expert Consultation is being made available as document UNEP/CBD/SBSTTA/5/INF/11.

* UNEP/CBD/SBSTTA/5/1.

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SUGGESTED RECOMMENDATIONS

The Subsidiary Body on Scientific Technical and Technological Advice may wish to recommend that the Conference of the Parties:

1. Takes note of the tools that have been used for the implementation of the programme of work on the conservation and sustainable use of marine and coastal biological diversity;

2. Takes also note of the results of the Expert Consultation on Coral Bleaching, as contained in document UNEP/CBD/SBSTTA/5/INF/11;

3. Requests the Executive Secretary to fully integrate the issue of coral bleaching in the programme of work;

4. Invites Parties and other Governments to develop and implement response measures to coral bleaching, taking into account those suggested by the expert consultation, and contained in annex II to the present note.

CONTENTS

INTRODUCTION

1. The Executive Secretary has prepared this note in order to assist the work of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) at its fifth meeting in the area of conservation and sustainable use of marine and coastal biological diversity. Specifically, as agreed by SBSTTA at its fourth meeting, SBSTTA is to consider implementation tools for the Jakarta Mandate programme of work (decision IV/5, annex). 1/

2. This note reviews in its section II the tools being used in the context of decision IV/5 and draws lessons learned in their development and application, which could be used in the development of further thematic and cross-cutting programmes of work under the Convention.

3. On the issue of coral bleaching, decision IV/5, section II, paragraph 1 of the Conference of the Parties, requested SBSTTA to make an analysis of the coral bleaching phenomenon and provide relevant information to the fifth meeting of the Conference of the Parties for its consideration. 2/ Section III of the note thus provides an analysis of the coral bleaching phenomenon.

I. IMPLEMENTATION TOOLS FOR THE PROGRAMME OF WORK

4. Specific activities within the Jakarta Mandate programme of work are currently being implemented successfully by the Secretariat (in collaboration with relevant bodies), according to ways and means identified in decision IV/5. In addition, Parties have established national mechanisms to implement actions to ensure conservation and sustainable use of marine and coastal biological diversity. Examples of such national mechanisms include committees for the formulation of integrated marine and coastal area management plans and programmes and expert committees on issues such as marine and coastal alien species and genotypes.

5. Elements and operational objectives of the work programme, which constitute the basis for action in the area of conservation and sustainable use of marine and coastal biological diversity by the Parties, other Governments, relevant bodies and the Secretariat are summarized in box 1 below.

6. Within each of the operational objectives, specific activities are to be implemented, through the use of appropriate tools. These are implementation tools used for the overall, international enhancement of the programme of work, which are to be beneficial and complementary to the tools and mechanisms used by the Parties in implementing the marine and coastal programme of work of the Convention

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1/ The programme of work sets out activities, ways and means to implement them, and time frames for the achievement of specific objectives, referred to as "operational objectives". The programme of work also refers to tools that can be used for implementing the above-mentioned activities.

2/ SBSTTA at its fourth meeting agreed that physical degradation and destruction of coral reefs also pose a significant threat to the biological diversity of these ecosystems and therefore recommended that the Conference of the Parties expand its request to the Subsidiary Body, as contained in its decision IV/5, so as to include the effects of such activities in addition to the analysis of coral bleaching. This aspect of coral bleaching is covered in the present note.

nationally. Tools include products that will facilitate the implementation of specific provisions of the Jakarta Mandate as a whole.

7. According to the scope of this note, annex I provides, in a tabular form, a description of each of the tools, including how these are intended to serve the implementation of activities and the achievement of operational objectives; the table also assesses the uses of the tools, their efficiency, criteria of success and/or limitations as well as the emerging or expected results and the lessons learned from their application.

Box 1

PROGRAMME ELEMENTS AND OPERATIONAL OBJECTIVES OF THE JAKARTA MANDATE PROGRAMME OF WORK

1. Implementation of integrated marine and coastal area management (IMCAM)

1.1 Reviewing existing instruments related to IMCAM

1.2 Promoting the development and implementation of IMCAM at the local, national and regional level

1.3 Developing guidelines for ecosystem evaluation and assessment (including indicators)

2. Marine and coastal living resources

2.1 Promoting ecosystem approaches to the sustainable use of marine and coastal living resources

2.2 Making available to Parties information on marine and coastal genetic resources, including bioprospecting

3. Marine and coastal protected areas

3.1 Facilitating research and monitoring activities on the value and effects of marine and coastal protected areas or similarly restricted management areas on sustainable use of marine and coastal living resources

3.2 Developing criteria for the establishment and management of marine and coastal protected areas

4. Mariculture

Assessing the consequences of mariculture for marine and coastal biological diversity and promoting techniques to minimize adverse impacts

5. Alien species and genotypes

5.1 Achieving better understanding of the causes and impacts of introductions of alien species and genotypes

5.2 Identifying gaps in existing or proposed legal instruments, guidelines and procedures and collecting information on national and international actions

5.3 Establishing an "incident list" of introductions

6. General

6.1 Assembling a database of initiatives on programme elements, particularly integrated marine and coastal area management

6.2 Developing a database of experts from the Roster of Experts and other sources for the development and implementation of national policies on marine and coastal biological diversity

II. ANALYSIS OF THE CORAL-BLEACHING PHENOMENON, POTENTIAL SEVERE LOSS OF BIOLOGICAL DIVERSITY AND CONSEQUENT SOCIO-ECONOMIC IMPACTS

A. Background

8. The Conference of the Parties, in its decision IV/5, expressed deep concern at the extensive and severe coral bleaching which occurred in the Indian Ocean, caused by abnormally high water temperatures experienced since January 1998. It also recognized the potentially severe loss of biological diversity and consequent socio-economic impacts of coral bleaching and noted this occurrence as a possible consequence of global warming.

9. In light of this, and consistent with a precautionary approach to this issue, the Conference of the Parties decided on two kinds of action: (i) firstly, it requested SBSTTA to make an analysis of the coral-bleaching phenomenon and to provide relevant information to the fifth meeting of the Conference of the Parties; (ii) secondly, it instructed the Executive Secretary to express its concern to the Executive Secretary of the United Nations Framework Convention on Climate Change (UNFCCC) and the Secretary-General of the Convention on Wetlands and to convey it to the conferences of the parties to UNFCCC and the Convention on Wetlands. The Conference of the Parties of the Convention on Biological Diversity also invited UNFCCC to urgently address this issue in its deliberations. The Executive Secretary conveyed the message to the secretariats of the two conventions in writing shortly after the fourth meeting of the Conference of the Parties; and reiterated it to the Conference of the Parties of UNFCCC at its fourth meeting (Buenos Aires, November 1998). The latter forwarded the issue to the attention of its Subsidiary Bodies on Scientific and Technological Advice and on Implementation (SBSTA and SBI, respectively). At their tenth joint session, the subsidiary bodies decided that the request of the Conference of the Parties to the Convention on Biological Diversity would be addressed by the Subsidiary Body on Scientific and Technological Advice only.

10. In line with the mandate given to him through decision IV/5, the Executive Secretary has prepared this section of the note, which summarizes the issue of coral bleaching, its causes, potentially severe loss of biological diversity, and consequent socio-economic impacts, in order to assist SBSTTA at its fifth meeting in its deliberations.

11. This section of the note benefited from inputs of experts involved in an Expert Consultation on Coral Bleaching organized by the Executive Secretary in order to assist him in the identification of the main scientific, technical and technological aspects related to the problem. This was in line with recommendation IV/1, paragraph 6, of SBSTTA at its fourth meeting that the Executive Secretary should make rapid progress on the issue of coral bleaching.

12. The Expert Consultation took place in Manila, Philippines, from 11 to 13 October 1999, with the generous contribution of two Parties, one Government and one international organization. The report of the Consultation is provided in document UNEP/CBD/SBSTTA/5/INF/11, which expands on some specific aspects of the problems and should therefore be read in conjunction with the present section of the note.

B. Importance of, and impacts on, coral reefs

13. Coral reefs are among the most important and extensive marine ecosystems in tropical regions of the world. They are often the most significant ecosystem, ecologically, culturally and economically, for many small island developing States. For example, in the Pacific region, reefs are vital to the survival of atoll countries, as they constitute the primary coastal protection structures on low lying tropical islands and provide sand for construction and beaches. They are also the major source of food and livelihood for low-income fishers and their families in many countries and provide critical habitats supporting major commercially valuable fish stocks such as tuna and mackerel. They provide critical habitat for many threatened migratory species, such as sea turtles and dugongs. They are also reservoirs of some of the highest marine biological diversity in the world, including genetic resources and bioactive compounds that will support the development of new pharmaceuticals, and serve as important environmental health indicators. The social, cultural and economic prosperity of tropical regions has been and will continue to be dependent upon the health of their coral reefs and related ecosystems. 3/

14. Until the exceptionally strong El Niño/La Niña events of 1997/98, the major factors threatening the survival of coral reef were direct anthropogenic factors: pollution from domestic sources, industry and agriculture; and over-exploitation of fishery resources, especially through the destructive practices of blast and cyanide fishing. It was estimated that 58 per cent of the world's reef resources were at high to medium threat of significant damage. 4/ The significant climate-related events of 1997/98 have dramatically enhanced our concerns for the future of coral reefs.

15. Reef-building corals, the main organisms structuring coral reefs, experienced additional massive stresses in many parts of the world as a result of increases (1-2^{o}C) in seawater temperatures above normal summer maximums over weeks to months during 1997/98. In some areas this was in combination with direct anthropogenic disturbances, whereas, in large areas of the world, corals on remote pristine reefs were seriously affected. This resulted in large-scale bleaching and in many cases massive mortality of the major corals, along with many other reef organisms.

16. Bleaching in corals is a response to stress and can be caused by a wide range of stresses. But the scientific consensus is that the most significant cause of bleaching results from elevated seawater temperatures. Corals will also bleach if exposed to extremes in almost any environmental variable e.g. extreme low temperatures, extremes in salinity, pollution, increased sedimentation, and excessive illumination.

17. Bleaching is the disassociation of the symbiosis between reef-dwelling invertebrates and their symbiotic dinoflagellate algae (zooxanthellae). This phenomenon manifests itself as a reduction in the coloration of the animal tissue as a result of reduced densities of symbiotic algae and/or of a loss in the

3/ Adapted from the International Coral Reef Initiative (ICRI) Pacific Regional Strategy, 1996.

4/ Reported in Bryant, D., L. Burke, J. McManus and M. Spalding (1998). Reefs at risk: a map-based indicator of threats to the world's coral reefs. World Resources Institute, Washington, D.C.

cellular concentrations of photosynthetic pigments. The precise mechanisms of how thermal stress leads to coral bleaching is poorly understood. There is increasing evidence that elevated seawater temperatures result in a disruption of the photosynthetic capacity of the symbiotic algae and/or an increase in the production of toxic oxygen radicals. Whether this breakdown in zooxanthellae function results in the algae abandoning the coral, or being actively expelled by the host is not certain.

18. Coral bleaching is not a new phenomenon and has been reported on coral reefs for over 100 years. However, recent examples of bleaching are more extreme than reported before. While bleaching on a local scale has been observed in the past, and may at this scale be a natural phenomenon, the current extent and severity of bleaching around the world is unprecedented.

19. Bleached corals are under increased stress as they are without their major energy producing systems, their zooxanthellae, which can provide up to 90 per cent of the carbon energy compounds. In this state, they are particularly susceptible to additional stresses. Under some circumstances, the corals recover either by regenerating their residual populations of zooxanthellae, or they capture new populations of symbionts from free living dinoflagellates. If the bleaching stress (or additional stresses) are either severe of prolonged, then most or of the coral polyps die. Bleached corals are also under far greater susceptibility to a wide range of pathogenic diseases and other stresses.

20. Bleaching events have increased in intensity, frequency and geographic distribution in the last two decades (Goreau 1964; Egana and DiSalvo 1982; Glynn 1993, Hoegh-Guldberg and Salvat 1995, Brown 1997; Wilkinson, 1999; Hoegh-Guldberg, in press; Reaser et al., in press). 5/ In 1998, the worst year on record, near complete loss of live coral cover in some parts of the world occurred. A recent analysis of reports of bleaching (Wilkinson, 1999) indicated that there is wide variability in factors such as bleaching intensity, number of species affected, local, depth and geographic distribution and, most importantly, how much mortality a bleaching event causes.

21. Bleaching reports span the world's three major oceans, in over 50 countries, which proved the global nature of the event (Wilkinson, 1999). Recent records include first time events, such as in the Maldives, Singapore, Palau and Japan, which caused unprecedented mass mortality of 85 per cent or more of the stony and soft coral populations, a drastic reduction in coral diversity, and the local extinction of some previously abundant coral species, with no evidence of recruitment (Wilkinson, 1999, Loya et al., in press).

22. The most severely impacted areas were in the Indian Ocean and Southeast and East Asia (Wilkinson, 1998; Wilkinson et al., 1999). Most reefs in the Central and Northern Indian Ocean suffered major mortality when warm surface waters, that were mapped through satellite imagery, ‘migrated’ from South to North in the Indian Ocean during the first six months of 1998. This corresponded to an extreme El Niño event that switched over to an equally strong La Niña event for the last six months of 1998, when many reefs in Asia profoundly bleached. In most of the Pacific Ocean, coral bleaching was either very minor or non-existent. A localized

5/ The list of references for this section of the present report is contained in annex III below.

bleaching event was reported in Samoa, probably due to an extreme low tide event and there has been rapid recovery (Skelton and South, unpublished data).

23. In the Caribbean, there were many reports of bleaching throughout, but in most cases there has been significant recovery with few residual impacts. However, during the recent bleaching event in Belize populations of the previously dominant coral Agaricia tenuifolia suffered heavy mortality and was replaced by algae (Precht & Aronson, 1999). Bleaching was intense and widespread in Puerto Rico, however, almost all bleached colonies of corals, zoanthids, anemones, octocorals and hydrocorals have recovered. This recovery included colonies that remained totally bleached for over 6 months (Weil, unpublished data).

24. While data are being assembled on the physical and biological impacts on coral reefs, the socio-economic consequences of this massive event are yet to be assessed and in many cases will not have manifested yet.

25. The increased intensity, frequency and widespread geographic occurrence of mass bleaching events are now considered by most reef scientists to be a serious challenge to the health of the world's coral reefs, in parallel with, or exceeding the direct anthropogenic impacts. Many scientists now believe that corals are living close to their upper thermal tolerance limits, and that small changes in water temperatures triggered by global climate change could trigger massive bleaching events. Sea surface temperatures (SST) in the tropics have increased by almost 1^{o}C over the past 100 years, and are currently increasing at the rate of approximately 1-2^{o}C per century (Hoegh-Guldberg, in press; Reaser et al., in press).

26. Thus there are two major anthropogenic stress categories for coral reefs: direct and local stresses (pollution and over-exploitation); and indirect, but global factors, including climate change. The former stresses are amenable for local management by countries with coral reefs, such as small island developing States, whereas the latter factors are external to these countries, and beyond their capacity for direct management. For example, Pacific island countries control enormous exclusive economic zones and an ocean area representing some 12% of the globe, but their contributions to climate change are infinitesimally small and their ability to mitigate changes are negligible. Thus concerns of such smaller countries are a particular concern for the whole international community.

C. Potentially severe loss of biological diversity due to coral bleaching

27. Coral bleaching represents a serious threat to coral reefs worldwide, particularly when such bleaching results in massive mortality of reef-building corals and other important sessile invertebrates. These losses have automatic consequences for reductions of biological diversity, and damage to reef communities, with the cascading effects that this will produce. When the frequency of the impacts exceed the capacity of the system to recover, then localized extinctions will be the result.

28. Bleaching-related mortality certainly results in drastic changes in biological diversity, in terms of: living coral cover; number of species and number of colonies/m^2; local extinction of coral species; and absence of recruitment (Loya et al., 1999). However, loss of biological diversity during coral-bleaching events is generally not well documented. Furthermore, in certain regions, baseline

knowledge of coral reef biological diversity is at best rudimentary or poor, and at worst non-existent. In the Pacific islands, biological diversity studies have been carried out at very few of the 8,000 or more islands of the region, and comprehensive biological diversity studies of selected sites are rare (e.g. the Suva Lagoon, Fiji). Even in such well-documented areas, only a fraction of the total biological diversity has been documented.

29. The indicators of change following bleaching events include: increase in macro-algal cover and biomass, decrease in fish biological diversity, increases in the incidence of ciguatoxic blooms and consequent human health consequences, plus many other less obvious and poorly understood impacts.

30. Certain corals are more resistant to bleaching than others, probably due to differences in physiological tolerances. This is demonstrated (for example by Loya et al., 1999) in the case of the Okinawa 1998 bleaching event, where the juveniles of the branching Acropora species showed greatest resistance to bleaching if compared with the most vulnerable adult corals.

31. In terms of effects at the ecosystem level, to date, information on changes to coral communities following coral bleaching is very limited, and there have been no projections on the long-term effects of bleaching on coral community structure (Brown and Suharsono, 1990; Gleason, 1993; Loya et al., 1999; Hoegh-Guldberg, in press). Scientists should make greater efforts towards narrowing this gap.

32. In light of our poor knowledge of potential impacts of coral bleaching on biological diversity, it seems important at this point to concentrate some efforts into gathering quantitative information on the relative proportions of bleached colonies within populations of the different species, their mortality and recovery rates, as well as on the local and geographic variability of these aspects.

D. Socio-economic impacts consequent to coral bleaching

33. Most of the coral reefs in the world are situated in and around developing countries where the majority of the population lives within 50 km of the coastline. Coastal communities are typically poor and are dependent on coastal resources and coral reefs for their livelihood. Fisheries provide a major income source for coastal communities and a significant source of animal protein in the diet. Coral reefs provide approximately 10 to 15 per cent of tropical fisheries production and support up to 30 million people in fishing households. Degradation of coral reef ecosystems is a major threat to sustainable fisheries production and coral bleaching could exacerbate this situation. For instance, along the reef coastline of Eastern Africa, around 50% of the estimated 100,000 full-time fishers and several hundred thousand part-time fishers risk losing their livelihood if habitat degradation and overfishing trends continue (Moffat et al., 1998).

34. Coastal tourism, particularly dive tourism, is another important income generating activity derived from healthy and biodiverse coral reef ecosystems. For instance, in the Maldives, 45 per cent of gross national product (GNP) stems directly and indirectly from tourism revenues. Dive tourism is a substantial portion of this total. Coral reefs also serve as natural barriers to protect the coastline from erosion. In Sri Lanka, severe coastal erosion has already occurred in areas where coral mining is taking place, and further damage to the reef structure from bio-eroded dead coral could carry a heavy financial cost. Revetments, and breakwater schemes to prevent further erosion are already costing

the Sri Lankan government approximately US$ 30 million (Berg et al., 1998). Coral bleaching may also be increasing incidences of ciguatera poisoning. Health impacts from coral bleaching can also include malnutrition due to declining fish production, loss of income and employment.

35. In addition to direct impacts from coral bleaching and associated coral mortality, related climate change induced impacts from El Niño events and elevated sea-surface temperatures (SST) can exacerbate poverty and other socio-economic consequences. Droughts, increasing frequency of storms and hurricanes, and changes in migration patterns of pelagic fisheries induced by climate change can lead to an increase in coastal erosion, a loss of drinking water supply, contamination of groundwater and related public health concerns, and lower fisheries yields, among others. The cumulative impacts resulting from anthropogenic sources, including coral bleaching, climate change and local unsustainable human use can push many coastal communities and households into deeper levels of poverty and frustrate efforts to improve their quality of life.

36. Given this dependency on the functions and services that the coral-reef ecosystem provides to hundreds of millions of people around the tropical oceans, the socio-economic impacts of massive coral bleaching are likely to be significant, especially in developing countries. They should be considered against the background of decades of rapidly deteriorating coral reefs all over the world, mainly due to human activities. General impacts may include loss of income and employment within communities and sectors dependent on coral-reef ecosystems, as well as increasing costs for prevention, mitigation, disaster relief and rehabilitation. The severity of socio-economic impacts will be dependent on several factors. These include:

(a) The severity, extent and frequency of ecological impacts associated with coral bleaching;

(b) The speed of recovery of the coral-reef ecosystems;

(c) The level of dependency of coastal communities on coral-reef ecosystems; and

(d) The diversity of productive activities within coastal households.

37. Impacts associated with coral bleaching can include some not directly associated with coral-reef degradation and coral mortality. Examples include a short-term decline in pelagic fishery harvests due to elevated sea-surface temperatures.

38. A precise estimate of the socio-economic impacts is difficult to make at this stage. This is due to the uncertainty surrounding many of the relationships between coral bleaching and mortality on the one hand and ecosystem services, such as fisheries, tourism and coastal protection on the other hand. The uncertainty with respect to socio-economic impacts also stems from yet unknown future coral recovery and adaptability of coral reefs, among other things. Many of the socio-economic impacts will only appear in the medium term and will be difficult to distinguish from impacts caused by localized unsustainable use, except in areas impacted by catastrophic and severe coral bleaching events. Finally, it is likely that coral bleaching events will become more frequent and severe over the next several decades, and where coral reef ecosystems may not have enough time to fully

recover. With this scenario, the cumulative socio-economic impacts from coral bleaching and elevated sea surface temperature will show a commensurate increase in severity and frequency.

39. The following two possible scenarios as well as many intermediate pathways are conceivable: (i) damage to the reef is not too severe and recovery is relatively rapid; (ii) damage is severe and there is very slow or no recovery, in which case the long-term impacts will be severe. It is not unlikely that the "low impact" scenario occurs in various locations with moderate bleaching, while the "high impact" scenario takes place in many locations with severe bleaching.

40. In the low-impact scenario discussed above, the likely socio-economic effects are:

(a) Some change in species composition, both in the water and in fishery landings. Initially, total fish productivity may increase with larger populations of herbivores, though there may be reductions in the catches of certain target fish for niche markets, such as the ornamental fish trade. Some pelagic fisheries may decline due to temporary migration from elevated sea surface temperatures;

(b) A possibly slight decrease in tourism-generated income and employment, as some dive tourists may stay home or go elsewhere, and most tourists will not alter their behavior. There may also be a temporary migration of large and small charismatic marine species important to niche dive tourism markets;

(c) No major change in the coastal protection function, as bio-erosion of dead reefs and coral growth of new recruits even each other out;

(d) Minor health related impacts from slight increases in ciguatera poisoning.

41. In the high impact scenario described before, socio-economic effects could be very severe:

(a) Harvestable productivity may drop considerably as the reef structure disintegrates resulting in reduced catches for the fishers, less protein in the diet, particularly for coastal communities, lower health status and declining nutrition particularly among the poorer segments of the community. Fishers could experience a major loss of income, loss of employment, loss of fish food sources, and reduced ability to purchase other food. This is exacerbated by some loss of pelagic fisheries production, which are partly reef-related. Coral reefs also provide critical habitats supporting commercially important pelagics, such as tuna and mackerel. Declines in these stocks impact the economy of the world’s fisheries.

(b) There may be major direct losses in tourism income and employment. This is especially likely when charismatic marine fauna disappears as a result of the bleaching and resulting mortality. Besides, eco-tourism income from existing sites as well as potential yet undeveloped sites might be severely reduced. This could mean a huge loss in potential future earnings in developing countries;

(c) A possible collapse of the protective barrier function of the reef could occur, resulting in greater coastal erosion. This would especially have large implications for atoll islands and low-lying coastal areas. This will be exacerbated by concurrent sea-level rise;

(d) A major outbreak of ciguatera with significant human health implications can not be excluded. Declining fish production and loss of income or employment opportunities can also lead to secondary impacts on health - a decline in nutrition within coastal communities.

42. Given these uncertainties, the range of possible losses due to coral bleaching is large. The full human suffering as a result of the coral bleaching and mortality event, due to possible malnutrition and worsened poverty damage as well as unemployment is more than dollar values can express. A preliminary attempt to estimate an economic value to the 1998 coral bleaching event in the Indian Ocean put the losses in the range of US$ 700 million to US$ 8,200 million (Wilkinson et al., 1999), and these figures for some island countries represent a major portion of their gross national product. Given the large uncertainties that exist with respect to the impact of bleaching on ecosystem services and their socio-economic consequences, more socio-economic monitoring and applied research is urgently needed to assess the damages to the peoples and to the economies around the tropical oceans.

E. Examples of current measures to address the phenomenon

43. Recognizing the severity and extent of the 1998 coral-bleaching events, the urgency required in responding to their impacts, and the potential for such events to occur in the future, some Governments, intergovernmental bodies and non-governmental organizations have already come forward to contribute initial resources to address the problem. Additional resources are necessary to guarantee the success of the critical research, monitoring and management measures.

44. The ICRI Renewed Call to Action contains the consensus of participating countries on how to address the protection and sustainable management of their coral reefs. This instrument will continue to advice countries on how to deal with phenomena such as coral bleaching; they are also relevant in the regional and global context, as they incorporate cooperation measures.

45. A Global Coral Reef Monitoring Network (GCRMN) was established back in 1994, 6/ with the role to document the status of coral reefs of the world with major reports every two years as the basis for improved coral-reef conservation. The 1998 report contained a compilation of data and anecdotal information gathered from e-mail correspondence on where (or where not) coral bleaching had occurred in 1997/98. This proves that much can be done through non-costly means such as electronic communication.

46. The Network is in the process of updating that report and placing it on the Internet as public information for use by decision makers, scientists, etc. The next report will concentrate on case-studies reported in 1998, but focus on more detailed assessments. Initial reports from 1998 were of massive damage in many areas, especially the Indian Ocean, East Asian Seas and parts of the Caribbean. Since then, some reports indicate considerable recovery, whereas others accurately

6/ The Intergovernmental Oceanographic Commission (IOC), UNEP, the World Meteorological Organization (WMO) and IUCN have joined forces to co-sponsor the GCRMN, which is hosted jointly by the Australian Institute of Marine Science and the International Center for Living Aquatic Resources Management. These bodies, along with the Secretariat of the International Coral Reef Initiative, form the GCRMN Management Group. Advice is provided by a widely representative Scientific and Technical Advisory Committee (GCRMN-STAC).

document major death of corals and apparent local extinctions of the more susceptible species.

47. Monitoring of coral bleaching can be achieved through all sorts of techniques, from field and ground-truthing activities (including diving) to more sophisticated activities such as remote sensing technology. Aerial surveys have been shown to be a cost-effective method for obtaining estimates of bleaching distribution and intensity over scales from 10-1000 km. The technique is most suitable where bleaching is severe, and thus conspicuous from the air. Recent highly specialized remote sensing methods that can potentially detect bleaching to a depth of 10m have been developed. If these methods can be perfected, it should be possible to monitor bleaching phenomena in both time and space using satellite imagery.

48. The use of satellites for monitoring the evolution of sea-surface temperatures regionally and globally has attained such a degree of maturity that nowadays they can be of great assistance in terms of anticipating and monitoring coral-bleaching phenomena.

49. The report of the Expert Consultation held in Manila in October 1999 (UNEP/CBD/SBSTTA/5/INF/11) also contains recommendations, specifically on the identification of crucial scientific gaps and uncertainties and of gaps in information about, and the knowledge of, the problem. The document also suggests measures to fill those gaps, and a related research agenda is proposed. Priorities for action and constraints are also identified, along with response options as well as the application of the ecosystem approach to the problem of coral bleaching, which refers to the need to develop an integrated knowledge of and an integrated approach to the issue that encompass ecological, traditional, and socio-economic aspects. As part of response measures that may be needed, there is a strong need to increase public awareness to the severity of the problem.

Annex I

TOOLS FOR THE IMPLEMENTATION OF THE JAKARTA MANDATE ON MARINE AND COASTAL BIOLOGICAL DIVERSITY

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Roster of experts on marine and coastal biological diversity	To contribute to further development of scientific, technical, technological and socio-economic issues	Decisions II/10, IV/5 and IV/16	• Peer reviews, clarifications or examinations of scientific, technical, technological and socio-economic issues; • Specific contributions to the compilation of documents; • Participation in global and regional workshops;	Pending development of uniform methodology for use of roster of experts 8/	• Roster has pilot function for other CBD rosters; • High quality of responses; • Limited capability of some experts to work in the designated working language; 9/	• Basis for a programme of work; • Knowledge base on specific issues; • Expert advice to the Executive Secretary; • Peer-review of documents;	• Lack of full understanding of roster function; • Lack of incentives for experts;

7/ (As of September 1999).

8/ See document UNEP/CBD/SBSTTA/5/15.

9/ For reasons related to budgetary constraints, written communication between the Secretariat and experts on the roster takes place mainly in English.

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Roster of experts on marine and coastal biological diversity	To contribute to further development of scientific, technical, technological and socio-economic issues.	Decisions II/10, IV/5 and IV/16	• Assisting in connecting the Jakarta Mandate and related programme of work to international, regional, national and local scientific, technical and technological processes.	Pending development of uniform methodology for use of roster of experts	• Need to respond properly to vast amount of expertise.	• Outreach of Jakarta Mandate and direct input back from experts.	• Communication on frequent basis needed to activate expertise; • Need to develop mechanisms to have experts communicate with each other.
Database of initiatives on programme elements, with special emphasis on integrated marine and coastal area management (IMCAM)	To inform on relevant initiatives, promote exchange of information and experiences among Parties, and strengthen cooperation with relevant organizations and bodies	Decision IV/5, annex, operational objective 6.1	Parties, other Governments, organizations and bodies, the general public, and other users of the Jakarta Mandate World Wide Web page	Being tested 10/	Limited access by some Parties to information available through electronic means (Internet)	• Availability of relevant information on initiatives at the international level and other resources; • Inter-connectedness of initiatives.	A significant number of initiatives relevant to the Jakarta Mandate are on-going, but information is sparse and coordination limited

10/ According to decision IV/5, the information will be made available through the clearing-house mechanism. The database will be posted on the Jakarta Mandate World Wide Web page (http://www.biodiv.org/jm.html) during October 1999.

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Database of experts from the roster and other sources 11	To assist in the development and implementation of specific elements of national policies on marine and coastal biological diversity, giving full recognition to the importance of taxonomy	Decision IV/5, annex, operational objective 6.2	• Internally: Assist the Secretariat to contact/choose experts for meetings, papers, etc. The database will also be a basis for creation of mailing lists and listservs • Externally: Give Parties, other Governments and relevant bodies the facility to know who and where the experts are and which areas they cover, and eventually contact them	• The way the database will run should include the opportunity for feedback on how to improve it; • Also depending on encouraging those countries who have not nominated any expert to do so; • Roster of experts maintenance team ?	• Most important criterion of success is the maintenance of the experts' information	To be assessed in the future (tool was launched in September 1999)	• Experts should be given the opportunity to check and correct (as needed) their own information
Informal task forces	To assist the Secretariat in: • Reviewing instruments; • Dealing with causes and impacts adverse to marine and coastal biological diversity; • Identifying appropriate approaches; • Developing guidelines and criteria	Decision IV/5, annex, paragraphs 11 and 14, and operational objectives 1.1, 2.1, 3.2 and 5.1	Secretariat	Excellent: communication takes place mainly through electronic means on almost a real time basis; task forces serve objectives common to all its members, which favors efficiency	• Related outputs being drafted and to be presented to the Conference of the Parties at its fifth meeting; • Time schedule of partici-pating organiza-tions sometimes different	Production of documents	Informal task forces are most efficient and cost-effective tools for implementation

11/ See also document UNEP/CBD/SBSTTA/5/15.

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Memoranda of cooperation	To formally agree on common operational objectives at the secretariat level	Decision III/21, paragraph 2	Secretariat	To be assessed through appropriate mechanisms	Degree of specificity of planned joint actions	• Improved harmonization at the programmatic level; • Better use of resources and expertise.	• Represent useful harmonization tools; • Must be accompanied by as a specific an operational annex as possible.
Ad Hoc Technical Expert Groups on: • Marine and Coastal Protected Areas • Mari-culture (see also document UNEP/CBD/ SBSTTA/5/ 15)	• To review proposals on research and monitoring projects on the value and effects of marine and coastal protected areas and identify the linkages between conservation and sustainable use; • To evaluate the current state of scientific and technological knowledge on the effects of mariculture and provide guidance on criteria, methods and techniques which avoid the adverse effects and enhance the positive effects of mariculture and stock enhancement	Decision IV/5, annex, operational objectives 3.1 and 4, respectively	Parties, other Governments and relevant bodies	Depending on expertise mobilized and time given for the tasks	• Resources available; • Quality of output(s); • Satisfaction of the Conference of the Parties.	Documents to be submitted to the Conference of the Parties	No experience yet

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Jakarta Mandate World Wide Web page	To promote the Jakarta Mandate and the programme of work for its implementation, and to disseminate relevant information	Several provisions under decision IV/10	Secretariat developed and updated the page, taking into account contributions from Parties and relevant organizations	• In theory very good, as information is concentrated logically organized and easily accessible for those who have access to Internet; • To be evaluated by the users.	Limited access to Internet	• Improved awareness; • Improved education; • To facilitate the identification of sources on which to make informed decisions.	Page ought to contain two kinds of information (for already informed users and for users non-familiar with the issues) but must in any event be easily accessible
Guidelines on integrated marine and coastal area management	To guide on how to address the conservation and sustainable use of biological diversity through the application of integrated marine and coastal area management (and taking into account benefit-sharing)	Decision IV/5, annex, operational objective 1.2	Parties and other Governments	To be assessed (guidelines will be presented at the fifth meeting of the Conference of the Parties)	• Number of countries that found the guidelines suitable • Limited capacity to apply guidance • Non-universality of certain guidance	Concrete guidelines	Several sets of guidelines already exist but do not address specifically enough marine and coastal biological diversity
Guidelines for ecosystem evaluation and indicators (see also document UNEP/CBD/ SBSTTA/5/ 12)	To assess ecosystem conditions and distinguish between natural and human-induced effects	Decision IV/5, annex, operational objective 1.3	Parties and other Governments	To be tested	• Number of countries that found the guidelines suitable • Limited application of certain indicators at the national level	Guidelines and indicators	Very few existing assessment guidelines and indicators at the ecosystem level

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Criteria for the establish-ment and management of marine and coastal protected areas	To guide Parties and other Governments in the establishment and management of those areas	Decision IV/5, annex, operational objective 3.2	Parties and other Governments	To be presented at the fifth meeting of the Conference of the Parties	• Number of countries that found the criteria suitable; • Countries' limited financial capacity and expertise.	Concrete global criteria	• Many sets of criteria already existing, but there is a need for a core set of them; • Strong harmonization required.
Study on the effects of stock enhancement on marine and coastal biological diversity	To assess the effects of stock enhancement at the species and the genetic levels	Decision IV/5, annex, operational objective 2.1, activity (f)	Parties and other Governments will use the results of the study, to be conducted by the Secretariat	Pending the realization of the study, its findings will assist in reducing negative and enhance positive impacts of stock enhancement on marine and coastal biological diversity	• Limited resources within the Secretariat to conducts the study; • Countries' technological limitations.	Desk study	Expertise is available at least within two partner organizations. However, cooperation is impeded by lack of resources to implement the activity
Gap analysis of legal instru-ments, guidelines and procedures on alien species and genotypes	To identify gaps in knowledge and regulations	Decision IV/5, annex, operational objective 5.2	Parties and other Governments	Pending completion of study by the Secretariat for the fifth meeting of the Conference of the Parties	• No particular limitation envisaged; • Coordination with other activities on alien species by SBSTTA and the Conference of the Parties.	Guidance to Parties, other Governments and relevant bodies	There are an extensive number of instruments, guidelines and procedures. Gaps are limited, but harmonization is lacking

TOOL	OBJECTIVE	LEGISLATIVE AUTHORITY	USES	EFFICIENCY	CRITERIA OF SUCCESS AND/OR LIMITATIONS	RESULTS EMERGING OR EXPECTED FROM THE UTILIZATION OF THE TOOL 7/	LESSONS LEARNED
Study on bio-prospecting of marine and coastal genetic resources, including those of the deep sea-bed	• To identify actions needed by the Convention; • To provide the Parties with a basis on which to make informed decisions.	Decision II/10, paragraph 12 ,and decision IV/5, annex, operational objective 2.2	Parties and other Governments	Pending completion of study for the fifth meeting of the Conference of the Parties	International policy agenda	Guidance to Parties, other Governments and relevant bodies	A regulatory tool at the international level (genetic resources of the deep seabed) is lacking

Annex II

CONCLUSIONS AND RECOMMENDATIONS ON
PRIORITY AREAS FOR ACTION 12/

A. Information-gathering

Issue: Our ability to adequately project, and thus mitigate, the impacts of global warming on coral reef ecosystems and the human communities which depend upon coral reef services is limited by the paucity of information on:

(a) The taxonomic, genetic, physiological, spatial, and temporal factors governing the response of corals, zooxanthellae, the coral-zooxanthellae system, and other coral-reef-associated species to increases in sea surface temperature;

(b) The role of coral reefs as critical habitat for marine species and natural resources for human communities;

(c) The current status of coral-reef health and threats to coral reefs; and

(d) The potential capacity of recovery 13/ of corals and resilience of the ecosystem after mass mortality.

Response:

(a) Implement and coordinate targeted research programmes, including predictive modelling, that investigate: (1) the tolerance limits and adaptation capacity of coral reef species to acute and chronic increases in sea surface temperature; (2) the relationship among large-scale coral bleaching events, global warming, and the more localized threats that already place reefs at risk; and (3) the frequency and extent of coral bleaching and mortality events, as well as their impacts on ecological, social and economic systems;

(b) Implement and coordinate baseline assessments, long-term monitoring, and rapid response teams to measure the biological and meteorological variables relevant to coral bleaching, mortality and recovery, as well as the socio-economic parameters associated with coral reef services. To this end, support and expand the Global Coral Reef Monitoring Network (GCRMN) and regional networks, and data repository and dissemination systems including ReefBase - the Global Coral Reef Database. Also, the current combined Sida-SAREC and World Bank programme on coral reef degradation in the Indian Ocean (CORDIO), as a response to the 1998 coral-bleaching event, could be used as an example;

12/ Source: Expert Consultation on Coral Bleaching (Manila, Philippines, 11-13 October 1999)

13/ Recovery is the return of a coral colony to a state of health, including a symbiotic relationship with zooxanthellae, after the health and/or symbiotic relationship has been disrupted by a stress or perturbation. Recovery may involve a change in the genetic composition of species of the zooxanthellae. Resilience is the return of a coral reef ecosystem to a state in which living, reef-building corals play a prominent functional role, after this role has been disrupted by a stress or perturbation. A shift toward high dominance by frondose algae accompanied by a reduction in the functional role of coral would indicate a situation of low resilience.

(c) Develop a rapid response capability to document coral bleaching and mortality in developing countries and remote areas. This would involve the establishment of training programmes, survey protocols, availability of expert advice, and the establishment of a contingency fund or rapid release of special project funding;

(d) Encourage and support countries in the development and dissemination of status of the reefs reports and case studies on the occurrence and impacts of coral bleaching.

Issue: The remoteness of many coral reefs and the paucity of funding and personnel to support on-site assessments of coral reefs requires that remote-sensing technologies are developed and applied in the evaluation of coral-bleaching events.

Response: Extend the use of early-warning systems for coral bleaching by:

(a) Enhancing current NOAA AVHRR HotSpot mapping by increasing resolution in targeted areas and carry out ground-truth validation exercises;

(b) Encouraging space agencies and private entities to maintain deployment of relevant sensors and to initiate design and deployment of specialized technology for shallow oceans monitoring; and

(c) Making the products of remote sensing readily accessible to coral reef scientists and managers worldwide with a view to those scientists and managers that are based in developing countries.

B. Capacity-building

Issue: There is a substantial lack of trained personnel to investigate the causes and consequences of coral bleaching events.

Response: Support the training of and career opportunities for marine taxonomists, ecologists, and members of other relevant disciplines, particularly at the national and regional level.

Issue: Coral bleaching is a complex phenomenon. Understanding the causes and consequences of coral bleaching events requires the knowledge, skills, and technologies of a wide variety of disciplines. Any action aimed at addressing the issue should bear in mind the ecosystem approach, incorporating both the ecological and societal aspects of the problem.

Response: Encourage and support multidisciplinary approaches to coral reef research, monitoring, socio-economics and management.

Issue: Public awareness and education are required to build support for effective research, monitoring, and management programmes, as well as policy measures.

Response: Build stakeholder partnerships, community participation programmes, and public education campaigns and information products that address the causes and consequences of coral bleaching.

C. Policy development/implementation

Issue: Nearly 60 per cent of the world's coral reefs are threatened by localized, human activities which have the potential to exacerbate the

impacts of coral bleaching events. Evaluations of the 1998 coral bleaching events suggest that marine protected areas alone may not provide adequate protection for at least some corals and other reef-associated species as sea surface temperatures rise.

Response: Use existing policy frameworks to implement the multiple conservation measures outlined in the ICRI Renewed Call to Action, and develop and implement comprehensive local to national scale integrated marine and coastal area management plans that supplement marine protected areas.

Issue: Most coral reefs are located in developing countries and the majority of the people living near coral reefs are often extremely poor. Thus, even minor declines in the productivity of coral reef ecosystems as a result of coral bleaching events could have dramatic socio-economic consequences for local people who depend on coral reef services.

Response: Identify and institute additional and alternative measures for securing the livelihoods of people who directly depend on coral reef services.

Issue: Coral bleaching is relevant not only to the Convention on Biological Diversity but also the United Nations Framework Convention on Climate Change and the Convention on Wetlands. The ultimate objective of the United Nations Framework Convention on Climate Change is to reduce emissions in a manner that 'allows ecosystems to adapt "naturally" to climate change'. The United Nations Framework Convention on Climate Change calls upon Parties to take action in relation to funding, insurance, and technology transfer to address the adverse effects of climate change. The Convention on Wetlands provides guidance on the conservation and wise use of wetlands, including coral reefs.

Response: Initiate efforts to develop joint actions among the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the Convention on Wetlands to:

(a) Develop approaches for assessing the vulnerability of coral reef species to global warming;

(b) Build capacity for predicting and monitoring the impacts of coral bleaching;

(c) Identify approaches for developing response measures to coral bleaching; and

(d) Provide guidance to financial institutions, including the Global Environment Facility, to support such activities.

Issue: Coral bleaching has the potential to impact local fisheries, as well as certain high-value commercial pelagic fisheries and coastal ecosystems.

Response: Encourage the Food and Agriculture Organization (FAO) and regional fisheries organizations to develop and implement measures to assess and mitigate the impacts of sea surface temperature rise on fisheries.

Issue: Coral-bleaching events are a warning of even more severe impacts to marine systems. If anomalous seawater temperatures continue to rise, become more frequent, or are prolonged, the physiological thresholds of other organisms will be surpassed. Not only will local fisheries be impacted, but certain high-value commercial pelagic fisheries and coastal ecosystems will be effected as well.

Response: Emphasize that coral bleaching can be monitored as an early warning of the impacts of global warming on marine ecosystems and that the collapse of coral reef ecosystems could impact ecological processes of the larger marine system of which coral reefs are apart.

Issue: The observations of the 1998 coral-bleaching events suggest that coral reef conservation can no longer be achieved without consideration of the global climate system and that it requires efforts to mitigate accelerated global climate change.

Response: Emphasize the interdependencies and uncertainties in the relationships among marine, terrestrial, and climatic systems.

D. Financing

Issue: Because the issue of climate change is global and long-term in scale, governments around the world need to work together to make funds available to implement initiatives to address the causes and consequences of coral bleaching.

Response: Mobilize international programmes and mechanisms for financial and technical development assistance, such as the World Bank, UNDP, the Global Environment Facility, regional development banks, as well as national and private sources to support implementation of these priority actions.

Annex III

LIST OF REFERENCES ON CORAL BLEACHING

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